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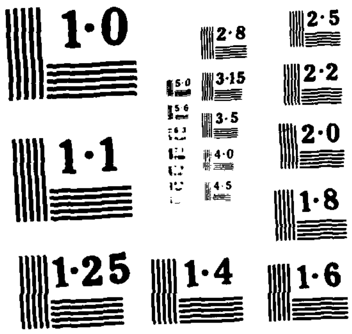
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NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

Sponsored by
NAVY ENERGY RDT&E OFFICE (ONT-07E)
~~NAVAL~~ FACILITIES ENGINEERING COMMAND

FACTORS THAT INFLUENCE THE IMPLEMENTATION OF ENERGY-SAVING TECHNOLOGIES AT NAVAL SHORE FACILITIES

June 1985

An Investigation Conducted by:
Oak Ridge National Laboratory
Oak Ridge, TN 37831

DE-AC05-84OR21400

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METRIC CONVERSION FACTORS

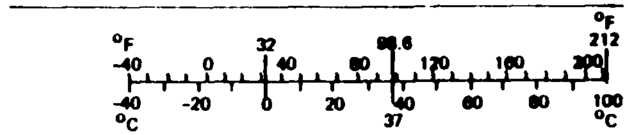
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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The purpose of this report is to assist the Naval Civil Engineering Laboratory in assessing the impacts of Energy RDT&E by identifying important factors that influence the adoption and continued use of energy conserving technologies at Navy shore facilities. Results of site visits and a survey of decision makers at Naval shore facilities in the

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Southeastern United States suggest that a significant barrier to adoption of new energy-conserving technology is the shortage of personnel to install, operate, and maintain new equipment. This situation enforces energy use patterns which may appear excessive, but which may be appropriate choices when guided by conditions of local manpower scarcities combined with the ability to draw on additional funds to cover unpaid fuel bills. A contributing problem is that only a small proportion of energy consumption activities are metered and many existing meters go unread. The inability to identify excessive energy users and to verify energy savings inhibits effective modifications of behavioral patterns and the introduction of new equipment.

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EXECUTIVE SUMMARY

The purpose of this report is to assist the Naval Civil Engineering Laboratory (NCEL) by identifying important factors that influence the adoption and continued use of energy-conserving technologies at Naval shore facilities.

Background

In response to severe petroleum shortages and rapidly escalating energy prices, the Department of Defense established in 1980, quantitative goals for reducing energy consumption at Naval shore facilities by 1985, 1990, 1995, and 2000. The Navy's response to the "energy crisis" included (1) creation of a variety of special funding programs for energy conservation projects; (2) authorization for designating an energy office within the Public Works Department (PWD) at Naval shore facilities; (3) enhancement of the provision of energy-related information through its engineering support system, particularly the Naval Facilities Engineering Command and NCEL; and (4) establishment of awards to facilities for outstanding energy conservation achievement.

NCEL tests products for their suitability for particular Naval civil engineering needs and disseminates its findings to facilities through publications such as Techdata Sheets. It also provides a telephone "hotline" for answering energy-related questions and has provided a cost-benefit evaluation system, tailored to specific products and technologies, to assist engineers at facilities in making economical decisions about energy conservation investments.

The present study examined the effectiveness of NCEL's contributions to the Navy's energy program. Printed materials were examined, five shore facilities and engineering support commands were visited for the purpose of interviewing personnel involved in energy conservation, and individuals involved in energy management at a number of different shore facilities were interviewed via written questionnaires at a Civil Engineering Officers School course on energy conservation. A majority of the data collected pertained to Naval shore facilities in the

Southeast, resulting in possible regional biases and restrictions on generalizing to facilities in other portions of the United States.

Full assessment of NCEL's activities required consideration of the institutional context within which NCEL's activities take place. Thus, this report covers a broad array of topics related to the Navy's energy program, not all of which can be altered by NCEL.

Findings

The term "energy conservation" draws mixed reactions among engineering personnel. It is widely believed that unit missions can be accomplished while improving the efficiency of energy use, but there is simultaneous concern that energy conservation and particularly attainment of the Navy goals may conflict with mission achievement. Officers tend to opt for mission achievement. There was also concern for the consequences of inadequately studied energy conservation measures, such as direct consumption curtailments.

The most significant single barrier to adoption of new energy-conserving technology is a shortage of personnel to install, operate, and maintain new equipment--or even maintain or repair old equipment. This situation enforces energy use patterns that may appear excessive but that may be appropriate choices when guided by conditions of local manpower scarcities combined with the ability to always draw on additional funds to cover fuel bills.

Inability to identify energy users and to verify energy savings inhibits effective modifications of behavioral patterns and the introduction of new equipment. Money for installing meters is severely limited, and personnel to read meters is inadequate.

All officers within PWDs deal directly with energy conservation activities, but their coordination with the Energy Officer is highly variable and frequently limited. Coordination among engineers and supply officers in arranging for purchase of energy efficient equipment also appears to be minimal, with the result that, as often as not, the equipment purchased is not the equipment required by the engineer.

Energy conservation investments using nonlocal funds appear to be more closely scrutinized economically than most other expenditures. The paperwork and time involved in making purchases are sizeable and burdensome. NCEL's cost-benefit calculation, known as the savings-to-investment ratio (SIR), has been of some help, and the Activity-Level Energy Systems Planning manual (A-LESP) should be an improvement. These tools, however, affect only the very beginning of a long, bureaucratic purchasing request procedure.

The Navy's energy information system is only vaguely familiar to a large proportion of its engineers involved in energy conservation. Techdata Sheets, a publication of NCEL, is the most well-known and highly regarded guide, but many users recommend alterations. Personnel involved in energy conservation are also variably aware of the engineering support available to them through the Naval Facilities Engineering Command's Engineering field divisions.

There has been an overinvestment in "glamour" technologies--particularly energy monitoring and control systems and solar devices. The former have multiyear lags between requisition and installation and between installation and successful operation. Many of the latter seem to be marginally cost-effective at best.

The Navy's energy goal structure measures energy savings in Btu's per square foot of floor space using 1975 as a base year for comparison. It is inadequate as a performance measure or as the basis of an incentive system. Activities within buildings are highly variable and change over time, making it difficult to identify actual improvements in energy efficiency through aggregate measures. Further, the Btu's generated by different fuels have different costs, leading to fuel switching which may be cost-effective and fuel conserving, but irrelevant to achieving the Navy's energy goals.

Recommendations

Our analysis of factors affecting the implementation of energy-saving technologies at Naval shore facilities has resulted in several key recommendations. Additional suggestions and background to the following recommendations can be found in sects. 4 and 5.

- The Department of the Navy must articulate its priorities regarding increased energy efficiency more clearly and forcefully if an energy program is to be effective; its energy goals should be modified to more accurately reflect Navy priorities.

- Given their relative prominence as a source of energy-related information, coupled with the existence of important information gaps on bases, Techdata Sheets should be updated more often, cover more topics, contain more operation and maintenance information, and include more specific information on products and manufacturers.

- Improved metering, meter reading, and energy consumption analyses are required for individuals and commands to alter their energy consumption behavior intelligently.

- Any efforts to reduce energy consumption must be linked to changes in operation and maintenance procedures and availability; lack of operation and maintenance resources is a major barrier to the achievement of energy savings at shore facilities.

- At the shore facility level, the various PWD Divisions and other departments should be better integrated into shore facility energy planning. In particular:

  - Priorities for energy-related maintenance control projects should be coordinated determinations between maintenance control and energy officers (EOs),

  - The energy conservation activities of family housing should be integrated with activities of EOs, and

  - Perceptions of conflicts between Supply personnel and EOs should be reconciled by closer coordination.

- Shared savings contracting appears to be one means by which many current barriers to the adoption of energy-conserving technologies can be overcome; guidance should be provided to shore facilities concerning its use.

1. INTRODUCTION

1.1 OBJECTIVES AND OVERVIEW OF THE STUDY

The purpose of this report is to assist the Naval Civil Engineering Laboratory (NCEL) in identifying important factors that influence the adoption of energy-conserving technologies at Naval shore facilities. Particular attention is given to those factors that NCEL can directly or indirectly affect and those factors which NCEL should consider in determining its future activities.

NCEL is an integral part of the Navy's technology delivery system. It is the principal Navy research, development, testing, and evaluation center for shore facilities, fixed surface and subsurface ocean facilities, and the Navy and Marine corps construction forces. It disseminates its findings through regular publications aimed at the Naval civil engineer audience. Additionally, it responds to specific requests for information from users in the field. NCEL's primary contribution to the Navy's energy conservation efforts is through the development and provision of technical information. The value of that information dissemination effort is best assessed by examining how that information can be and is used within what could be called the institutional structure of the Navy.

The relevant portions of the Navy institutional structure contain several identifiable elements. First is the command/responsibility/authority structure which affects de facto priorities, accomplishes missions, and pays bills. Second is the information system, which involves the production and delivery of technical information, commercial information, and metering of current energy use. Much of the problem surrounding efficiency or inefficiency of energy use hinges on information in one or more forms. A third element can be conceptualized as a budgetary environment. The final element, possibly motivating the actions within the other three sectors, is the Navy's set of energy conservation goals.

The remainder of this chapter describes in detail these various portions of the Navy system, including the Navy's technology delivery system, Department of Defense (DOD) energy goals, funding assistance for energy conservation, information and technical assistance, and other support for energy conservation. Section 2 clarifies the term "conservation" and discusses the Navy's energy conservation efforts within an economic framework based on supply, demand, and pricing considerations. Section 3 summarizes the study's research design, including its two major data collection efforts and our methods of analysis. Section 4 discusses energy conservation with the technology currently existing at a shore facility. Topics include metering, operation and maintenance budget limitations, individual behavior, perception of energy conservation, and integrating more officers into energy planning. Section 5 discusses investment in new energy-conserving technologies, including savings-to-investment ratios and related factors, information gaps and uncertainties surrounding investments, funding restrictions and administrative procedures, securing the cooperation of support personnel, inadequate complementary inputs and the goal structure. Section 6 presents a set of recommendations based on the findings of the study.

1.2 THE NAVY'S TECHNOLOGY DELIVERY SYSTEM

The Navy engages in a variety of technology delivery activities: it generates new technology internally in its laboratories and through industrial contractors and it disseminates information about technological developments internally and to industry in order to stimulate the use of appropriate technologies (Hough, 1983). The portion of the technology delivery system of particular interest here is the implementation of new energy-conserving technologies at Naval shore facilities. A diagram of the relevant system is shown in Fig. 1, and a list of acronyms appears at the end of this report.

The Naval Facilities Engineering Command (NAVFAC) executes a program of research, development, testing, and evaluation (RDT&E) for shore facilities and other operations. NCEL works directly under NAVFAC in matters of RDT&E. It is the principal RDT&E center for shore and offshore facilities and for support of Navy and Marine Corps construction forces. A significant portion of NCEL's RDT&E in support

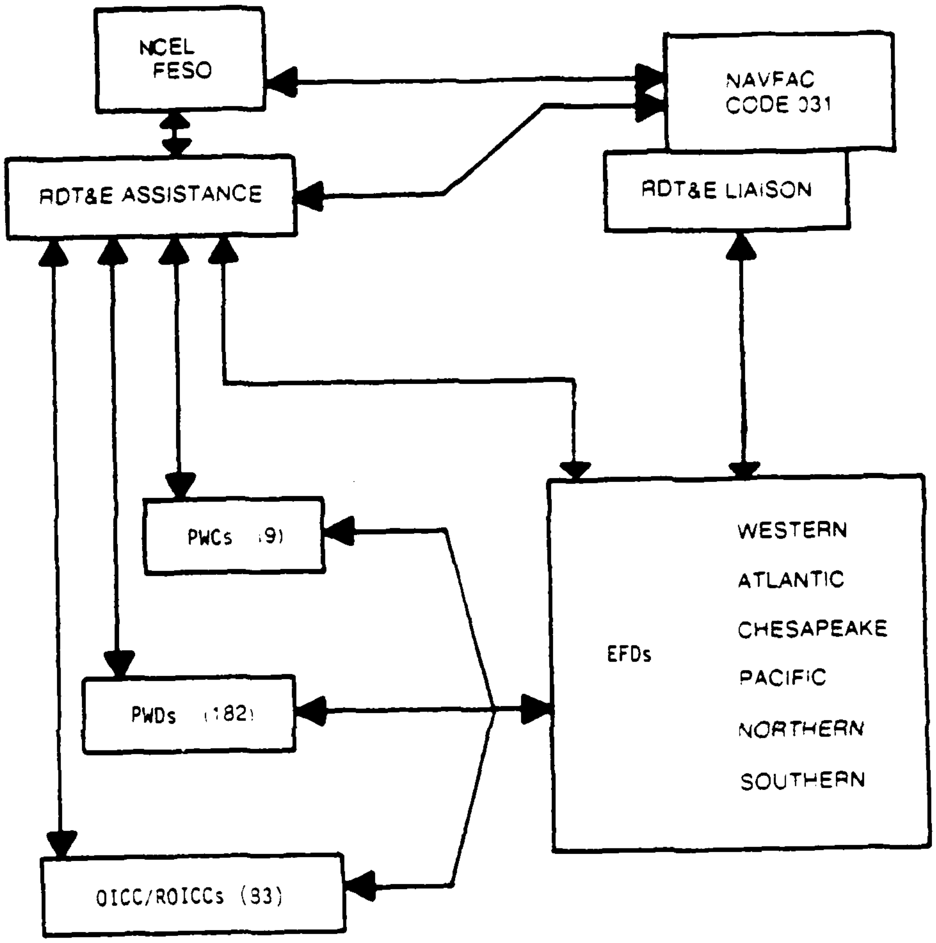

Fig. 1. The Naval Facilities Engineering Command (NAVFAC) RDT&E assistance and liaison programs. Source: Early, 1975.

of the Naval shore facilities is in the areas of shore and harbor facilities, environmental pollution abatement, and energy conservation (Early, 1975).

The Facilities Engineering Support Office (FESO) is a one-man office, which coordinates services and communications related to RDT&E assistance to Naval shore facilities. It is in a liaison position between NAVFAC (NCEL) and the field activities, serving to influence the research program through the identification of user needs and ensuring the application of research results in the field.

There are six Engineering Field Divisions (EFDs) which provide further liaison between NAVFAC (NCEL) and the field. They transmit expressions of need for research and development (R&D) in specific areas to NAVFAC and pass the results of R&D to people in the field.

The end-users of this technology transfer assistance are nine Public Works Centers (PWCs), approximately 180 Public Works Departments (PWDs), and 80-odd NAVFAC construction sites. The latter are manned by an Officer in Charge of Construction (OICC) or a Resident Officer in Charge of Construction (ROICC).

1.3 THE NAVY'S ENERGY PROGRAM

As with most government and commercial organizations with extensive physical plants, the Navy's interest in energy planning can be traced to the 1973-1974 time frame, which was characterized by severe petroleum shortages and rapidly escalating energy prices. From the Navy and DOD perspectives, two concerns were paramount. First, the high cost of petroleum was forcing the Navy to divert funds from mission-related tasks to routine energy payments. Second, prices were being controlled by foreign sources under threat of imposed shortages; national security mandated that the Navy have continuous, uninterruptible fuel supplies for the fleet.

In this environment, it was essential for the Navy shore establishment to reduce its consumption of energy. This effort became a high-priority program within NAVFAC.

In 1980, DOD established quantitative goals for reducing the energy consumed by Naval shore facilities. A reduction in petroleum-based fuel consumption and a shift toward the use of solid fuels and renewable energy sources were also mandated. These goals are shown in Table 1. The energy and petroleum reduction goals are based on baseline figures for FY 1975. The energy goals are further specified in terms of energy consumed per gross square foot of building area.

Activity progress in achieving the energy reduction goals is tracked on a quarterly basis by the Naval Energy and Environmental Support Activity (NEESA). NEESA compiles data related to the types of fuels used and associated costs, which serve as input into a DOD monitoring system known as the Defense Energy Information System II (DEIS II). Both DEIS II and NEESA's Energy Audit Report are used by top-level management to assess installation progress in reducing energy usage.

This report deals only with the Navy's Energy Program as it pertains to shore facilities. These facilities account for one-third of the Navy's total energy consumption, at a cost of $887 million in 1983. The fact that shore facilities have reduced their energy consumption per square foot by only 11% between 1975 and 1983 suggests that the DOD 1985 goal of 20% will be difficult to achieve and that the Navy's energy program needs improvement (Navy Energy Office, 1984).

1.3.1 Funding Assistance

A variety of funding assistance programs for energy conservation projects are available to Naval shore facilities. The funding sources and procedures depend in large part on the cost of the project.

Repair projects of less than $75,000 and minor construction and alteration projects that do not exceed $25,000 can be funded from available facility operations and maintenance budgets. The Activity Commanding Officer has funding authority over these projects.

A key source of external funds is the Energy Technology Applications Program (ETAP). It provides funding for alterations, upgrading, and repair of facility energy systems to improve energy

Table 1. DOD energy goals for Naval shore facilities

Goal	FY 1985	FY 1990	FY 1995	FY 2000
Percent reduction[a] in energy consumed per gross square foot	20	25	30	35
Percent energy obtained from coal and renewable sources	10	15	20	35
Percent energy obtained from renewable sources	1	5	10	20
Percent reduction in petroleum-based fuels consumption	30	35	40	45

[a]Relative to FY 1975. Source: Department of the Navy. 1984. Navy Activity-Level Energy Systems Planning Procedure.

efficiency which cost less that $200,000. Eligible projects include the installation of Energy Monitoring and Controls Systems (EMCS), more efficient lighting systems, solar thermal systems, and other such technologies. ETAP projects are reviewed and funded by major claimants and validated by EFDs.

The Energy Conservation Investment Program (ECIP) provides funding for ETAP-type projects that exceed $200,000. NAVFAC prioritizes and manages ECIP, and EFDs validate ECIP project submissions. Funding for most ECIP projects is provided through the Navy or Naval Reserve's military construction appropriations, or via the Navy's family housing appropriations.

Other funding arrangements exist that are not specifically earmarked for energy projects. These include major claimant level projects for minor construction projects up to $200,000 and unspecified minor construction projects for projects costing less than $500,000. There are also new financial initiatives available to shore facilities, such as venture capital procurement and shared savings contracting. With shared savings contracting, the Navy enters into an agreement with a private energy management company, which obtains financing for and carries out the development, installation, and maintenance of energy efficiency improvements at a facility. In return, the company receives a percentage of the energy cost savings realized as a result of their actions.

1.3.2 Information and Technical Assistance

Support through the provision of energy-related information is also variously provided by the players shown in Fig. 1. NAVFAC, through its Energy Engineering Program, funds Facility Energy Plans (FEPs) for shore facilities, which are written primarily by private architectural and engineering consulting firms. These plans, developed on a 6-year cycle, identify and assess energy conservation opportunities, including retrofits for existing facilities, replacement of existing facilities, operation and maintenance actions, and management actions. They also assess the installation's progress in meeting established energy goals.

Additional Navy facility energy-related documents exist. These include

1. P manuals (provide data, procedures, and guidance on Navy facility energy use);
2. technical data sheets (provide brief economic and technical guidance on new technology);
3. waste watchers guide (provides previously issued technical data sheets);
4. handbooks (provide design information for alternative materials and procedures, by NCEL);
5. technical memoranda, notes, and reports (document RDT&E efforts by NCEL);
6. instruction documents (provide high-level continuing guidance of Navy facilities energy programs);
7. design manuals (establish criteria for design of Naval Facilities, issued by NCEL);
8. NAVFAC guide specifications (establish minimum requirements for construction materials, workmanship, and contract maintenance, issued by NAVFAC);
9. type specifications (earlier versions of items 1 through 8); and
10. operation and maintenance manuals (establish minimum requirements for operation and maintenance of systems and facilities by Navy personnel).

Of particular significance to this study is a document recently developed by NCEL and released by NAVFAC in 1984. The Activity-Level Energy Systems Planning (A-LESP) manual provides a procedure for identifying and prioritizing facility energy conservation opportunities. The procedure involves three steps: (1) identify feasible energy options, (2) establish the economic viability of feasible options, and (3) establish energy goal categories (such as those shown in Table 1) and funding sources for economically viable energy options. Critical to the second step, and to the procedure as a whole, is the calculation of a measure of cost-effectiveness--the savings-to-investment ratio (SIR).

The SIR operates as a benefit-cost calculation and captures a number of relevant characteristics of a potential energy conservation investment. Its formulation is $SIR = (S_E + S_{OM})/C$, where S_E is the present discounted value of anticipated energy savings from an energy conservation investment, S_{OM} is the present discounted value of operating and maintenance costs associated with the investment, and C is the initial investment cost plus the present value of any replacement investment distinct from maintenance costs anticipated over the lifetime of the investment.

NCEL provides engineering information relevant to the site specific calculation of S_E and S_{OM} for particular investments, as well as discount rates and anticipated rates of increase in fuel prices. A base engineering officer can then calculate an SIR for each investment with cost and benefit data specific to the base.

1.3.3 Other Support for Energy Conservation

Quarterly reports on the Golden 25 and the Dirty 25 identify those facilities that have made the largest and smallest contributions toward Navy-wide energy goals. The incentive effects of these reports are not certain, but activity commanders note their inclusion, particularly on the Dirty list. The lists do appear to have an effect on awareness.

Several awards exist that provide incentives to energy conservation at Naval shore facilities. Annual Secretary of the Navy awards allow the winning bases to fly an "energy conservation flag." A number of major claimants provide a monetary award for energy conservation, which is allocated to winning bases. Finally, a Navy instruction permits individuals to be nominated for the Federal Energy Efficiency Awards.

2. THE NATURE OF CONSERVATION AND THE NAVY'S ENERGY CONSERVATION EFFORTS

2.1 THE NAVY'S ENERGY CONSERVATION PROBLEM

Widespread concern was encountered in interviews that conservation of energy could endanger individual units' accomplishments of their assigned missions and that, in the large, "excessive" attention to energy concern by the Navy could jeopardize its entire mission. There is evidence that the term "conservation" raises concern for mission accomplishment. This section examines the basis for this observed concern and suggests reconciliations of the Navy's collective desire to spend less on energy and its personnel's individual desires to accomplish their missions.

The term energy conservation requires clarification. For the nation as a whole, it has come to mean "sacrifice", "lowering of living standards", and "decreased productivity" (Blumstein, et al., 1980). A more useful definition of conservation is derived from economic theory, which introduces notions of efficiency and optimality. Efficient use of materials is guided by conditions of supply, price, and social cost.

One major impetus for economically rational conservation arises when prices do not reflect true social costs. The Navy has an energy pricing problem in addition to the market price problem possibly facing the nation. The Navy has difficulty in presenting consumption agents at their facilities with an array of prices for fuel and other materials that the Navy Department faces in the Congress and the marketplace. The Navy faces a set of energy prices--and prices of other goods used in the accomplishment of its mission--that identify the proper fuel usage, but the public organizational structure of the Navy and the imperative character of some of its missions make the intraorganizational transfer of materials at specific market prices difficult. Personnel in any particular command can authorize particular quantities of material for particular time periods, and these relative quantities, considering the difficulty of this augmentation, determine a set of relative prices for that command. The materials will be used generally in accordance with those "shadow" prices. Since the concept of a shadow price is so important to the Navy's energy conservation problem, we devote Sect. 2.2 to distinguishing between shadow prices and "market" or "cash" prices.

2.2 THE CONCEPT OF SHADOW PRICE

People typically use prices to decide how much of various items they want to purchase. However, prices are unreliable guides to resource allocation decisions when they do not reflect the true availability of items. Many circumstances can cause stated prices to inaccurately reflect supply conditions. In the Navy engineering system, a common source of this problem is the existence of restrictions on maintenance labor employed, due to "ceiling points". The pervasiveness of the problem makes the distinction between shadow and stated prices important for understanding and predicting how resources will be allocated.

A shadow price is the real cost facing a consumer for an item; it need not equal the actual "cash" price paid. Suppose that labor costs a shore facility $4.00 per hour and energy costs $1.00 per hundred thousand Btu. The command has a given budget of twenty million dollars which it spends fully on labor and energy. If it spent it all on labor, it could hire 5 million hours (roughly 2500 full-time employees for a year), or could buy approximately 28 million gallons of jet fuel if it spent all of its budget on fuel. The "cash" price (or cost) of a worker in terms of jet fuel is 28 million gallons divided by 2500 workers, or 11,200 gallons per worker.

Now suppose that the shore facility can hire only 20 full-time workers, and if it overspends on jet fuel it can dip into a "special fund" to "buy" some more. Substitute 20 for 2500 in the denominator of the jet fuel cost of a worker and note that the "shadow price" of a worker goes up to 1.4 million gallons of jet fuel. Now, if the facility dips into the reserve fuel kitty and the numerator rises above 28 million gallons, the shadow price of a worker rises accordingly. Note also that the shadow price of fuel is just the inverse ratio--fuel in terms of the workers that have to be sacrificed for it. Of course, if all twenty workers can be kept when the facility uses the reserve fuel kitty, the effective shadow price of the extra units of fuel is zero.

2.3 ENERGY CONSERVATION THROUGH CURTAILMENT OR EFFICIENCY IMPROVEMENTS

A particular problem regarding energy use in the Navy is that funds for fuel supplies augmentation are generally quite easy to obtain, leaving the shadow price of energy to responsible personnel artificially low. Expanding energy use and conserving on other scarce resources such as manpower and equipment is both efficient and rational from the local perspective. The problem is that the Navy wants to reduce operating costs by reducing fuel bills, possibly on the implicit reasoning that the relative fuel shadow prices, which most Naval requisitioners face individually, are cheaper than the market price the Navy as a whole faces.

Ideally, conservation efforts would attempt to "correct" the discrepancy between local shadow price ratios (such as the ratio of artificially low energy "price" to artificially high maintenance labor "price") and the price ratios existing in the rest of the economy. One way to accomplish this correction is to reduce the amount of energy which activities are allowed to use. Local activities would use absolutely and relatively less energy in pursuit of their missions, which would move Navy energy use patterns toward greater efficiency, as judged by energy and labor costs in the national economy.

However, if attention were focused only on the improvement of relative efficiency achievable by curtailment of energy use, without compensating increases in other resources, a decline in mission accomplishment levels would surely occur. Some opportunities for pure reductions in waste undoubtedly exist (e.g., in turning off barracks lights at particular times), but these windfall savings opportunities appear to be quite limited. The Navy must ensure that energy use curtailments are compensated with appropriate changes in other resources, either in budget expansions for maintenance or in the purchase, installation, <u>and maintenance</u> of improved equipment. Appendix A describes this argument in greater detail.

2.4 IMPLICATIONS

The analysis presented in Sect. 2.3 indicates the compatibility of achieving a facility's mission while at the same time increasing energy efficiency. It also indicates the necessity of increasing nonenergy inputs to compensate for reductions of energy. Local energy use practices may be cost-efficient in light of restrictions on manpower, but the resultant energy use patterns are probably inefficient in the context of market prices. Manpower reallocations must be made at local levels to compensate for mandatory reductions in energy use if individual unit missions are not to be jeopardized. Sufficient energy cost saving should be generated throughout the Navy to be able to pay for additional manpower (and other input) requirements.

3. RESEARCH DESIGN

The research design involved two major data collection efforts: (1) site visits to Naval shore facilities and (2) a survey of Navy and civilian personnel attending a Navy course on energy management. Integration of the data collected with the results of previous research leads to our conclusions and recommendations.

To confine ourselves to a manageable data collection effort, we chose a set of energy-conserving technologies for detailed study. The criteria for selecting these technologies were determined in collaboration with NCEL. We wanted the technologies to include a broad range of savings to investment ratios. However, local SIR calculations were not available. Two other criteria were used instead to ensure substantial variations in the technologies studied:

- Level of adoption. The technologies should range from high to low levels of current use at Naval shore facilities. It is expected that barriers will be different for technologies which few facilities have implemented than for technologies which have nearly reached "full market penetration" across facilities.

- Level of investment. The technologies should span the spectrum of no-cost to expensive investments, thereby including those paid for locally by maintenance or repair budgets, and those paid for Navy-wide through ETAP and ECIP.

The technologies selected jointly by ORNL and NCEL for case study are

- solar water heaters,
- high-pressure sodium lights,
- energy monitoring and control systems (EMCS), and
- polyurethane foam insulation.

These appear to meet both selection criteria. The survey data indicate that only 37% of Naval shore facilities have solar water heaters, while 77% have high-pressure sodium lights. Further, the technologies range from low-cost (i.e., installation of a single high-pressure sodium light) to ECIP-level costs (i.e., adoption of an EMCS).

3.1 OVERVIEW OF SITE VISITS

The site visits were conducted during June and July 1984. Altogether, 25 people were interviewed, and four PWDs, one PWC, one EFD, and one major claimant were visited (see Table 2). All of these facilities are in the Southeast, resulting in possible regional biases and restrictions on generalizations to facilities in other portions of the United States. One of the four PWDs visited is at a Marine Corps Air Station, two are at Naval Air Stations, and one is at a Naval Station. Thus, the sites vary considerably in their major mission. The inclusion of PWDs and a PWC was desirable because of their different organizational arrangements. PWCs manage large concentrations of Naval activities, and pay the utility bills for the energy consumed by the entire cluster. PWDs manage much smaller operations.

To maintain the anonymity of our interviewees and thereby facilitate candid conversations at the site visits, the names of those people interviewed are not divulged. Interviews at the four shore facilities followed the protocol shown in Appendix A. The questions were divided into three sections dealing with (1) characteristics of the person interviewed, including job responsibilities and energy-related education; (2) characteristics of the base, such as its energy conservation investment procedures and utility metering; and (3) characteristics of a set of energy technologies that facilitate or inhibit implementation. In addition to the information obtained through these interviews, a variety of documents were collected, including energy instructions and facility energy plans.

3.2 OVERVIEW OF CECOS SURVEY

Following the site visits, a survey was conducted of participants in a course on "Energy Management at Shore Facilities," held in July 1984 at Norfolk, Virginia. The five-day course is part of the Navy's Civil Engineering Corps Officer School (CECOS). Participants in the survey were primarily from the Atlantic and Chesapeake regions of the United States. Thus, the findings of the survey (as with the site visits) may have some regional bias. Questionnaires were distributed to

Table 2. Summary of personnel interviewed at site visits

Personnel	Number of interviews
Four public works departments	
Public works officers	1
Assistant public works officers (APWD)[a]	3
Energy officers and technical assistant	6
Director of engineering and engineering personnel	4
Director of utilities	1
Facilities planning personnel	2
Director of maintenance and control	2
Director of family housing	1
Public works center	
Production officer	1
Engineering field division	
Director of utilities division	1
Head of energy and utilities branch	1
Head of programs section	1
Head of engineering section	1
Major claimant	
Energy management officer	1

[a]One APWD is also the energy officer and is counted in both rows.

approximately 65 Navy and Marine Corps registrants. Of those questionnaires returned, 38 came from Navy registrants working in the continental (primarily the Southeastern) United States. These 38 responses comprise the survey database analyzed in subsequent sections. The current positions of respondents are summarized in Table 3. Note that the job descriptions of 12 of the 38 respondents deal directly with energy. The next largest group deals with facility planning. It is estimated that one-half of the individuals surveyed are civilian.

The questionnaire is shown in Appendix B and is divided into several parts: definition of the respondent's job, support for energy conservation on base, the importance of various information sources, and questions concerning barriers and incentives to the adoption of the four technologies: solar water heaters, high-pressure sodium lights, energy monitoring and control systems, and polyurethane foam insulation.

3.3 METHODS OF DATA ANALYSIS

The data collected in the site visit interviews and the survey of CECOS participants are presented and discussed in Sects. 4 and 5. Methods of analysis are limited to descriptive statistics because of the small sample sizes and the possible regional biases.

Table 3. Participants in CECOS survey

Position	Number of respondents
Energy officer, manager, or engineer	8
Director, manager or staff of facilities planning	5
Energy technical assistant, inspector, or EMCS instrument mechanic	4
Supervisory or staff mechanical engineer	4
Supervisory or staff civil engineer	3
Shop engineer or engineering technician	2
Electrical engineer or technician	2
Public works officer	2
Assistant public works officer	1
Environmental engineer	1
Mechanical engineer	1
Supervisory general engineer	1
Industrial engineer	1
Assistant in production officer	1
Assistant for special projects	1
Manpower division officer	1
Total number of respondents	38

4. ENERGY CONSERVATION WITH EXISTING TECHNOLOGY

Although NCEL is concerned primarily with the dissemination of information concerning technologically new equipment, a significant component of any improvement that will occur in the efficiency of the Navy's energy use will be accomplished with existing equipment. This section identifies several salient problems that the Navy faces in its effort to use energy more efficiently via the technologies already in place at shore facilities.

4.1 METERING

Metering of energy use is strikingly inadequate at Naval shore facilities. Many buildings and uses are not metered at all. Results from the survey of CECOS participants indicate that only 38% of shore facilities are metered well enough to identify large users of energy. This may be due, in part, to the fact that ECIP and ETAP funds do not include support for metering. Many of the meters which do exist are not read because of manpower shortages. At some shore facilities, civil engineering personnel do not even know which buildings are metered. There are rational efforts at some shore facilities to meter the largest, reimbursing energy users; but there exist significant, non-reimbursing energy users.

Without metering, problem energy users cannot be identified. Even conservative energy users (would-be energy savers) cannot determine the results of their efforts at improving efficiency without knowledge of this consumption. In fact, 50% of the respondents to the CECOS questionnaire identified the inability to measure energy savings as a major obstacle to the adoption of new energy-saving technologies (Fig. 2).

We recommend that more effort be made to meter energy consumption and to collect and analyze the resulting data. The requisite funds to purchase meters could be reduced, at least temporarily, by buying portable meters. Manpower requirements for reading metered data could be minimized by installing systems that record energy usage via phone or

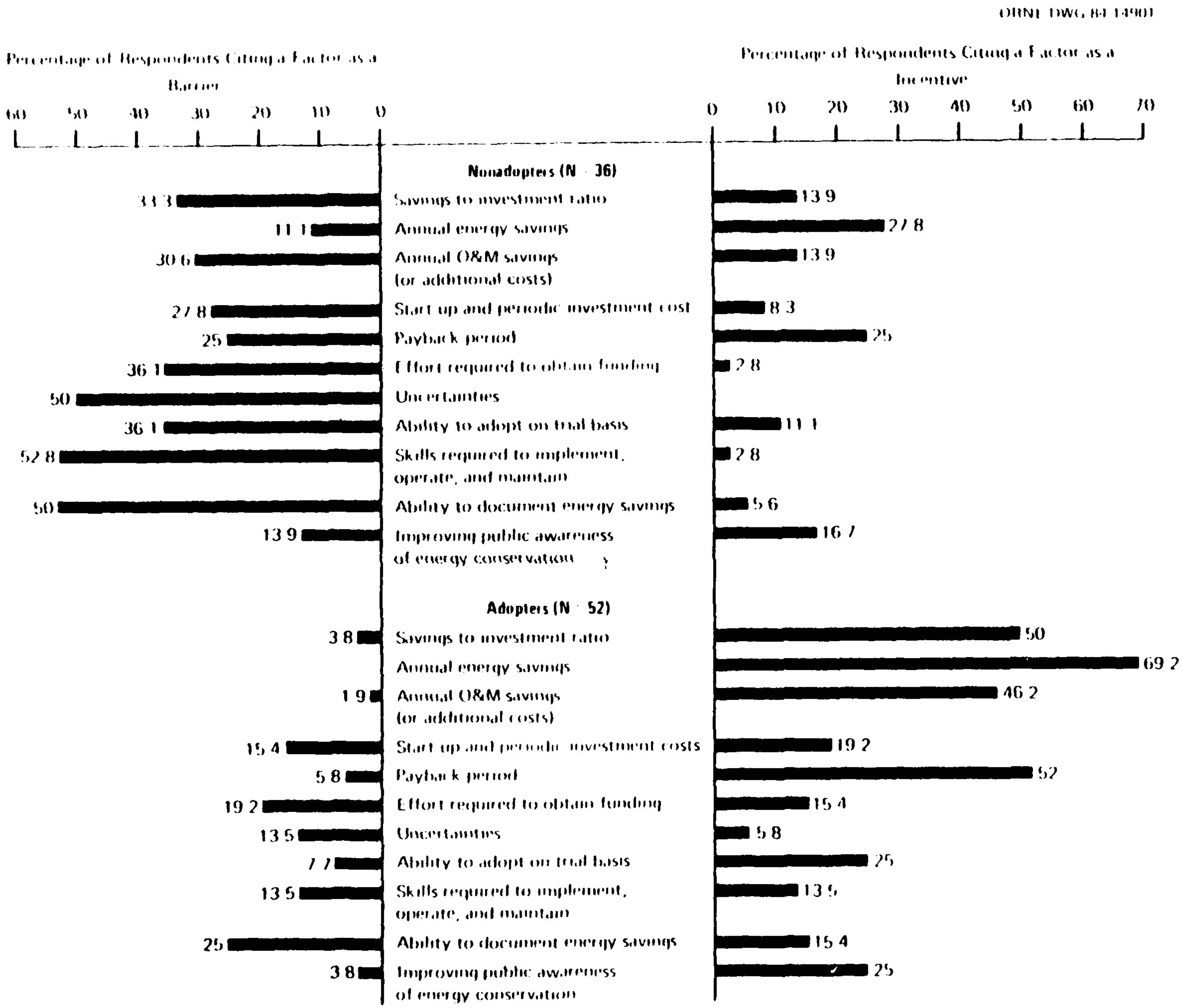

Fig. 2. Barriers and incentives to the adoption of energy technologies. (Entries in the figure are the percentage of respondents who cited an incentive or barrier as "3" or "4" on a four-point scale of importance. The energy technologies studied include solar water heaters, high-pressure sodium lights, energy monitoring and control systems, and polyurethane foam insulation.)

cable television lines. Associated computer software could help to analyze the information generated by metering in order to understand the causes of energy consumption patterns and to learn how to change them.

It is true that meters, in and of themselves, do not save energy. It is equally true, however, that without the consumption information provided by meters, it is very difficult to assess the effects of energy conservation efforts and to determine whether these efforts are cost-effective.

4.2 OPERATION AND MAINTENANCE BUDGET LIMITATIONS

The scarcest resource at shore facilities appears to be not energy or equipment or even money, but manpower. In many activities, preventive maintenance on operating equipment is an unaffordable luxury; only repair maintenance is conducted. We found several instances of equipment remaining idle for as long as two years for want of a simple replacement part. Energy officers often do not purchase equipment simply because they know it will not perform with the zero level of maintenance available.

The scarcity of maintenance manpower raises its shadow value (see Sect. 2) to local activities far above its market value. This high shadow value enforces energy use patterns that may appear excessive when judged by the standards of market prices, but that may be appropriate choices when guided by conditions of local manpower scarcities combined with the ability to always draw on additional funds to cover fuel bills. The energy use patterns established by these conditions will not be altered consequentially by demands to save energy with no other changes in external circumstances.

4.3 INDIVIDUAL BEHAVIOR

Individuals, not buildings or equipment, use energy. Thermostat regulation and lighting practices are conducted largely in circumstances in which individuals face zero prices for their consumption. Even if metering were successfully installed, personnel may find little or no individual incentive to conserve because individual users cannot be identified or changed accordingly. However, orders from commanding officers to modify behavior could have the effect of imposing an individual energy pricing system on all members of a command. "Thou shalt" and "thou shalt not" commands enforced with military discipline have proven highly effective for the military in a wide range of circumstances and represent a major test of energy consumption behavior modification available to the Navy. It is a commonplace observation that action is more likely in an organization when it has the attention of high-level managers (Chakrabarti and Rubenstein, 1976). Similarly, in an analysis of 156 firms in the State of Georgia which had recent plant energy audits, Sassone and Martucci (1984) found that an index of management commitment to energy conservation was the best predictor of compliance with audit recommendations.

Without the interested and active support of unit commanders, difficult-to-monitor patterns of individual energy use will remain largely unchanged. With such support from commanders, behavior can be changed, and efficiency of energy use may be improved. Support of commanders would have the effect of at least partially replacing the implicitly free goods policy toward individual energy consumption with a rational pricing system.

4.4 PERCEPTION OF ENERGY CONSERVATION

Although an overwhelming number of the CECOS questionnaire respondents thought that their units' missions could be accomplished with lower expenditures of energy, it was commonly reported during our site visits that unit commanders strenuously resist a wide array of energy consumption efficiency measures as representing threats to the accomplishment of their units' missions. This finding is possibly typical of the armed forces. In a previous study of a tactical engagement simulation technique in the U. S. Army, distraction from training was a key factor forestalling use (Scott, 1980).

There does not appear to be widespread confidence that directives to conserve energy are intelligent efforts to improve overall mission efficiency rather than consumption curtailments for the simple sake of reducing energy use. Such a potentially controversial curtailment is mandated in the Energy instructions of at least one Southern Naval shore facility, where the "comfort" air conditioning season is limited to June 15 through September 15.

The Navy command bears some responsibility for the perceptual conflicts regarding energy conservation and the rationalization of energy use. As noted in Sect. 2, not all conservation is efficient. Some activities involve a higher ratio of energy use to other inputs such as manpower or equipment, but the Navy-wide exhortation to save a blanket percentage of energy by 1985 does not acknowledge this diversity. Neither does the method chosen to measure attainment of the energy savings goal. The lack of penalties for nonattainment of the Navy energy goals at individual shore facilities may represent the Navy's recognition of the difficulty of measuring improvements in energy efficiency and the shortcomings of the current measure. However, it also conveys the message that it is a low priority endeavor.

The Navy needs to assess the (1) dollar value of potential improvements in the efficiency of its energy use and (2) the associated enhancements to, or detractions from, the ability to perform its various missions. It may decide that potential morale problems associated with imposition of energy pricing systems via military discipline are an excessive price to pay for the potential energy cost savings that may be forthcoming. Alternatively, it may find that with the rearrangement of local resource (e.g., manpower) availability, such pricing policies are effective. But without letting the answer precede the question, the Navy should decide, at a fairly high level of authority, on the relative importance of increases in energy use efficiency to the accomplishment of its missions and should signal its decision clearly to its commands.

4.5 INTEGRATING ENERGY INTO FACILITY ENGINEERING PLANNING

One important way that attention to particular issues (such as energy efficiency) is allocated within organizations is by routines. Information of importance is likely to be overlooked if it is not attended to on the basis of standard organizational rules (Stern and

Aronson, 1984). Our survey of CECOS participants indicates that routines do not always exist within the various Divisions of PWDs and PWCs, through which energy concerns and the expertise of the EO are considered.

The CECOS questionnaires indicate that engineers working in energy-related activities have very little awareness of family housing divisions (Fig. 3). There are extensive opportunities for energy use conservation in family housing, which itself often is directed by personnel without engineering backgrounds. Family housing personnel appear to have encouraged more efficient energy use (as indicated by the 17% reduction in energy use per square foot of housing which has been achieved since 1975). However, it is likely that these personnel could be helped by being brought more fully into energy planning activities at the shore facilities.

A good deal of equipment changeover which actually amounts to investment in new energy-saving technology is done under the rubric of maintenance control divisions because funding is less restrictive and less paperwork is involved. For example, if a building has any wall insulation at all, a complete reinsulation is possible under the title of maintenance, but the installation of any insulation in an uninsulated building must be undertaken as a new investment project. Switching of light bulbs similarly can be undertaken as a maintenance action. In many of these projects, better coordination between Energy officers and maintenance control on the one hand and Supply on the other would improve efforts to conserve energy, conducted under the title of maintenance. Often, noncommunication results in the purchase of nonoptimal or even inappropriate equipment, and several experiences of this sort can discourage requisitioners from trying to introduce new equipment.

The majority of energy-related engineering decisions are made by maintenance control and engineering personnel, often independently of the Energy officer (although a number of engineering divisions show plans to the Energy officer prior to completion). However, SIRs for energy-related investments are generally calculated by Energy officers for the small percentage of energy-related engineering actions which are

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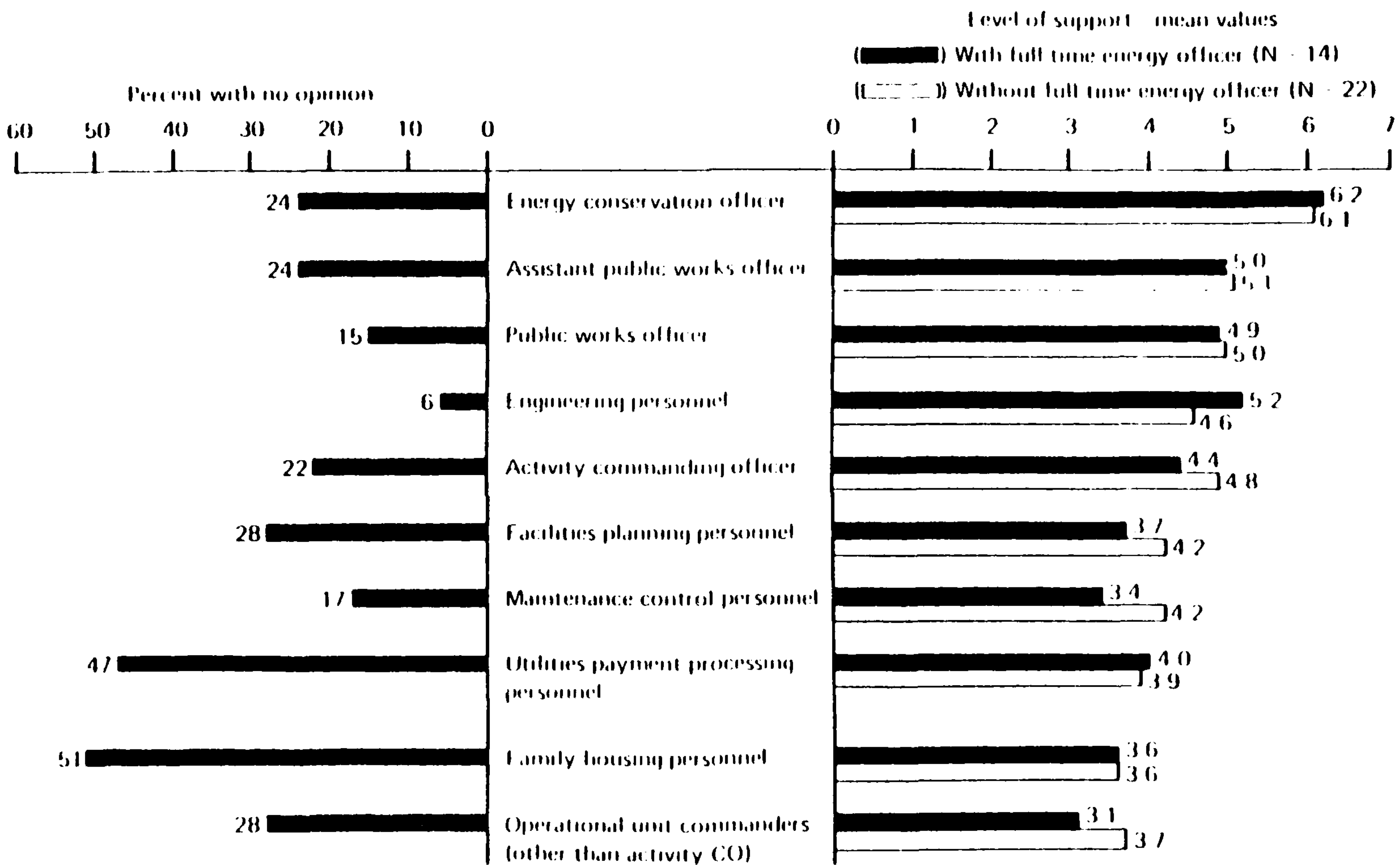

Fig. 3. Support for energy conservation. (Responses are measured on a seven-point scale varying from 1 = "no support or cooperation" to 7 = "strong support and cooperation.")

undertaken as nonmaintenance projects. Better coordination between maintenance control, particularly, and the Energy officer could offer some of the planning power contained in the SIR calculation efforts to a much larger share of the energy-related engineering projects. As NCEL's A-LESP manual is distributed, such coordination could become even more beneficial.

5. INVESTMENT IN NEW ENERGY-CONSERVING TECHNOLOGIES

5.1 SIR AND RELATED ECONOMIC FACTORS

Navy documentation such as the A-LESP manual prescribes criteria that should guide shore facility investment decisions with respect to energy-conserving technologies. In all instances, SIR is seen as relevant and should exceed 1.0 before a technology is purchased. Level of investment is also important; low-cost and no-cost projects are to be given top priority.

Additional guidelines are relevant depending on source of funding. For activity level construction and repair projects, NCEL recommends payback periods of six months or less. For major claimant projects, technologies should have a payback period of 18 months or less. It is recommended that unspecified minor construction projects result in savings in maintenance and operating costs which exceed the cost of the project within 3 years. Finally, ETAP projects should be self-amortizing, with a ratio of at least 15 M Btu's for every $1000 of project costs.

Thus, each of the following five "economic" criteria are legitimate concerns for investment decision-making:

1. savings-to-investment ratio (SIR),
2. annual energy savings,
3. annual operation and maintenance savings,
4. start-up and periodic investment costs, and
5. payback period.

These five criteria were evaluated in the CECOS survey. Our findings underscore their importance in decisions to adopt new technologies. Figure 2 shows that the above five factors are the most important incentives for adoption. The converse, however, is not true. These five criteria are not the most important factors in decisions to postpone or reject a technology. That is, they are not viewed as the most important barriers by nonadopters. In many instances, the economic evaluation of a technology is favorable, but other factors inhibit adoption. We describe noneconomic incentives leading to the overadoption of technologies in Sect. 5.2 and discuss "noneconomic" barriers to adoption in Sects. 5.3 through 5.7.

5.2 "GLAMOUR" AND THE OVERADOPTION OF ENERGY TECHNOLOGIES

A consistent finding of the technology transfer literature is that new technologies are frequently adopted for a variety of "noneconomic" reasons. Innovators (that is, those people and organizations which adopt an innovation early) have a greater price inelastic demand than subsequent adopters, which is recognized by distributors who set high, "market skimming" prices in the early stages of a technology's life cycle. Innovators are often attracted by the "gadgetry" of a new technology, the "glamour" of owning it, and the associated "prestige." Such factors frequently lead to overadoption or conspicuous consumption of new technologies. The spread of S.W.A.T. teams in municipal police departments (Feller and Menzel, 1977), computerized axial tomography (CAT scanners) in hospitals (Banta, 1980), and Harvestore silos by American farmers (Rogers, 1983) are examples of such "technologies gone wild." Solar technologies appear to be prone to overadoption, as well.

Table 4 provides evidence that overadoption of certain energy technologies may be occurring at Naval shore facilities. (This table disaggregates the information presented in Fig. 2, by type of energy technology.) Solar water heaters and high-pressure sodium lights appear to be adopted by many shore facilities for reasons other than favorable economic indicators such as high SIRs. For instance, the payback period was seen as a barrier to two of the seven adopters of solar water heaters and was an incentive to only one of them. For high-pressure sodium lights, only two of 17 adopters viewed the payback period as an incentive. The ability to experiment on a trial basis and to improve public awareness of energy conservation were judged to be equally, if not more important factors. Although "glamour" and "prestige" were not examined specifically in the CECOS survey, it is likely that they are also leading to the adoption (if not the overadoption) of some energy-conserving technologies.

Table 4. Incentives (I) and barriers (B) to the adoption of energy technologies[a]

	Solar water heaters		High pressure sodium lights		EMCS		Polyurethane foam insulation	
	I	B	I	B	I	B	I	B
Nonadopters	(N=12)		(N=5)		(N=9)		(N=10)	
Savings to investment ratio	1	8	1	1	2	2	1	1
Annual energy savings	3	4	2	0	3	0	2	0
Annual O&M savings (or additional costs)	1	7	1	1	2	1	1	2
Start-up and periodic investment cost	1	5	1	1	1	2	0	2
Payback period	2	7	2	0	4	1	1	1
Effort required to obtain funding	0	5	0	3	0	3	1	2
Uncertainties	0	4	0	2	0	5	0	7
Ability to adopt on trial basis	1	6	0	2	0	4	3	1
Skills required to implement, operate, and maintain	0	6	0	3	0	7	1	3
Ability to document energy savings	1	7	0	3	1	5	0	3
Improving public awareness of energy conservation	2	2	1	1	2	2	1	0
Adopters	(N=7)		(N=17)		(N=20)		(N=8)	
Savings to investment ratio	2	1	0	0	19	0	5	1
Annual energy savings	4	0	5	0	19	0	8	0
Annual O&M savings (or additional costs)	1	1	2	0	15	0	6	0
Start-up and periodic investment costs	1	2	6	1	2	4	1	1
Payback period	1	2	2	0	17	1	7	0
Effort required to obtain funding	1	3	3	1	2	5	2	1
Uncertainties	0	1	0	1	2	5	1	0
Ability to adopt on trial basis	5	1	4	0	2	2	2	1
Skills required to implement, operate, and maintain	0	0	4	0	2	5	1	2
Ability to document energy savings	0	1	2	1	4	2	2	1
Improving public awareness of energy conservation	4	0	3	1	4	1	2	0

[a]Entries in the table are the number of respondents who cited an incentive or barrier as "3" or "4" on a four-point scale of importance.

5.3 INFORMATION GAPS AND UNCERTAINTIES SURROUNDING INVESTMENTS

The existence of investment-related uncertainties and major information gaps is underscored by the survey of CECOS participants. For instance, the three most frequently cited factors preventing adoption are each related to a knowledge problem. In half of the decisions not to adopt a new technology, "uncertainties" were seen as a significant barrier; the inability to document energy savings was cited with similar frequency; and in 53% of the cases, "skills required to implement, operate, and maintain" a technology were viewed as a major hindrance to implementation (Fig. 2 and Table 4).

Although the nature of uncertainties inhibiting adoption of new energy technologies was not probed in the CECOS survey, the site visits along with findings of previous studies provide insight. First, there are uncertainties concerning the implementation and performance of the technology. There are related uncertainties regarding which manufacturers offer what products and the comparative performances of different brands of equipment in different circumstances. Then there are uncertainties surrounding the likely future cost of energy. Further, there is the possibility that a new technology will improve so rapidly that early adoption only leads to rapid obsolescence. This latter concern appears to be characteristic of residential solar photovoltaic systems and likely characterizes other new energy technologies (Katzman, 1981).

Further evidence concerning information problems is provided in Figs. 4 and 5. In rating the usefulness of various organizations and publications as sources of information on energy conservation, nearly half of the survey respondents had no familiarity with FESO, and large proportions of respondents were unaware of key energy-related publications. Techdata Sheets, for instance, were not known to 21% of those people surveyed. Thus, the Navy is faced with a major education problem in its energy program.

Of the publications examined in the survey of CECOS participants, NCEL's Techdata Sheets were judged to be the most useful source of information on energy conservation. Other publications were also rated

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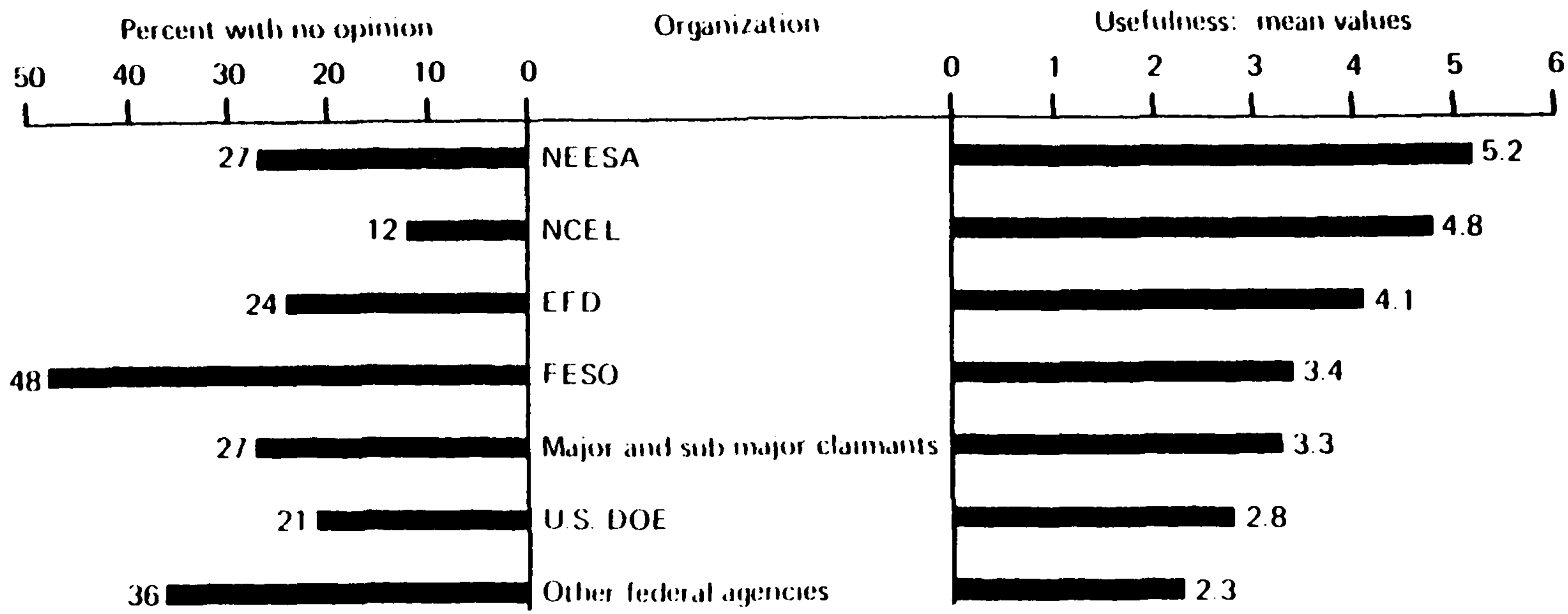

Fig. 4. Usefulness of organizations as energy conservation information sources. (Responses are measured on a seven-point scale varying from 1 = "not at all useful" to 7 = "extremely useful.")

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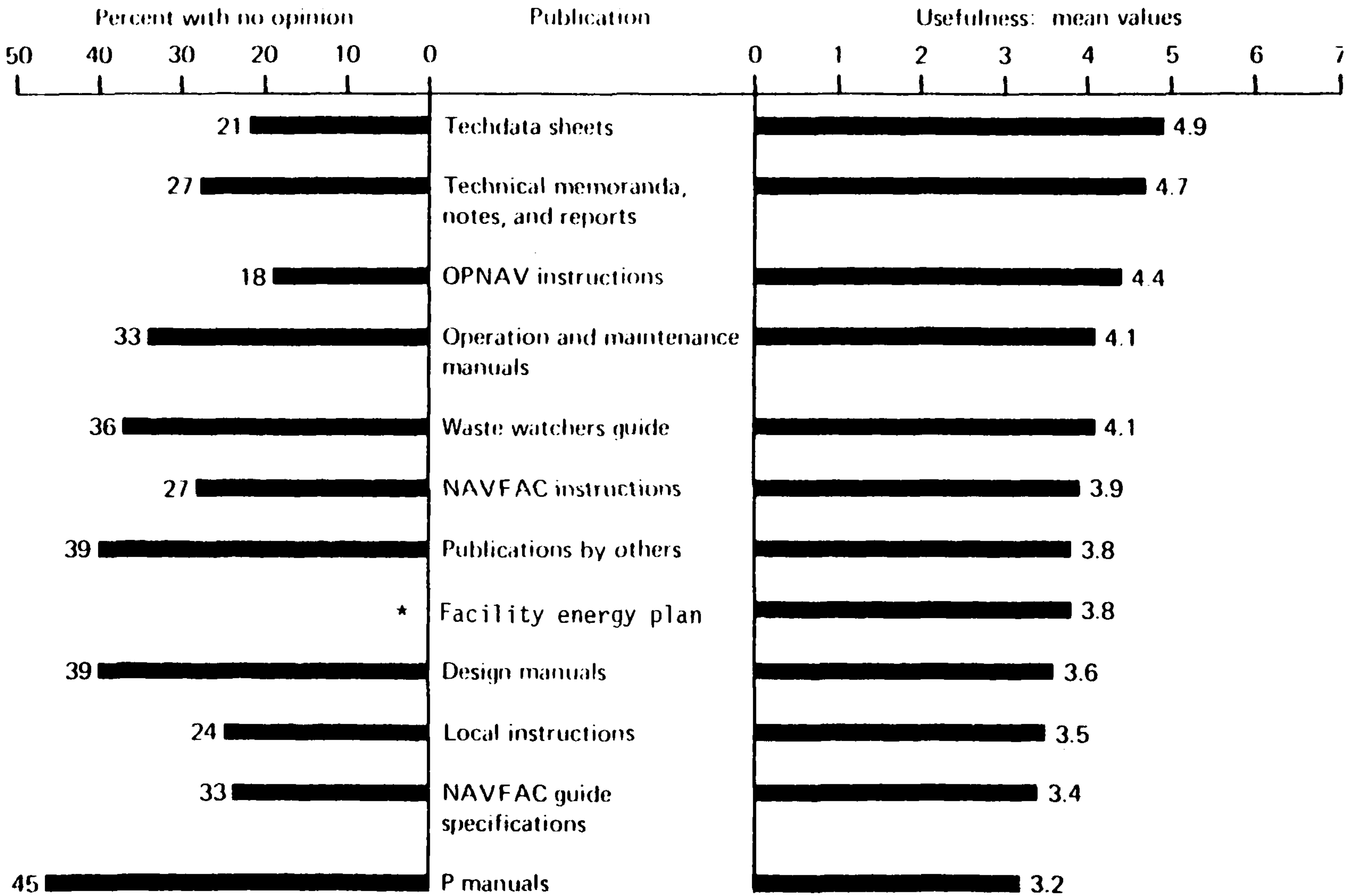

*This figure is not reported because of an error on the questionnaire.

Fig. 5. Usefulness of publications as energy conservation information sources. (Responses are measured on a seven-point scale varying from 1 = "not at all useful" to 7 = "extremely useful.")

above the midpoint on a scale ranging from "not at all useful" to "extremely useful". These include technical memoranda, notes, and reports, OPNAV instructions, operation and maintenance manuals, and the waste watchers guide. Other Navy publications were judged to be ineffective--including FEPs. The vast amount of literature on energy conservation published by the U.S. Department of Energy (DOE), the U.S. Department of Housing and Urban Development (HUD), and others were given a mediocre rating of 3.8, and 39% indicated a lack of familiarity with such "publications by others." Our site visits provide some insight into problems associated with some of the publications studied.

A variety of opinions were expressed concerning improvements to NCEL's Techdata Sheets. Several respondents indicated that the Sheets need to provide more operation and maintenance material (e.g., a discussion of steam trap maintenance options) and more information on particular brands and manufacturers. Many felt that some Techdata Sheets need to be updated and more should be written. Similarly, FEPs were seen as occurring too infrequently. Finally, several respondents at our site visits noted that the considerable resources offered by DOE and HUD publications were not being exploited by the Navy because of a lack of awareness.

The A-LESP manual was not evaluated in our survey questionnaire because of its newness. However, the type of information it contains appears to be highly appropriate--particularly the assistance it provides in calculating regionally specific SIRs. As indicated by a later discussion of funding procedures, the calculation of SIRs for energy technologies is currently seen as an arduous task by several of the EOs and facility planning personnel we interviewed during site visits.

Information gaps are likely to be a chronic problem in the Navy's energy program because of the frequent job rotations of military personnel. The civilian personnel in PWDs and PWCs tend to be the institutional memory. One way to reduce this information problem is to facilitate the development of communication networks between Energy Officers. Networking would allow EOs to better learn from the successes and failures of others faced by similar climatic and organizational circumstances. There is evidence from a variety of studies that personal communication among peers in similar positions in different firms speeds adoption of a practice (Stern and Aronson, 1984).

5.4 FUNDING RESTRICTIONS AND ADMINISTRATIVE PROCEDURES

A variety of funding restrictions and cumbersome administrative procedures inhibit implementation of energy-saving technologies at Naval shore facilities. The severity of the problem is indicated from the CECOS survey. More than one-third of the nonadopters indicated that the "effort required to obtain funding" was an important barrier, and almost one-fifth of the adopters judged this same factor to be an important hindrance.

The paperwork required for ECIP and ETAP funding is considered tedious, in part because it requires an economic analysis that includes the calculation of SIRs. Further, there are substantial time lags between ECIP/ETAP applications and funding, resulting in frustrations at shore facilities that are trying to deal with their energy problems on a timely basis. The funds available from ECIP and ETAP are also quite limited, both in size and in the projects they will support (e.g., metering is not an eligible expense, by itself).

A-LESP will help EOs and facility planning officers to complete the requisite economic analyses. Facility energy plans can and some do help in this regard by including all the necessary paperwork for external funding of recommended projects. The time lags and funding limitations and restrictions, on the other hand, require alterations of the procedures and priorities of the Department of Navy and its major claimants.

5.5 SECURING THE COOPERATION OF SUPPORT PERSONNEL

Cooperation among different officers on base has already been identified as a problem in trying to conserve energy without the introduction of new technologies. It becomes even more important when new technologies are introduced and, in addition, often involves the using clientele as well.

The most important specific link at which inter-office coordination becomes crucial when introducing new technologies is with Supply. Energy officers often have in mind specific equipment for particular projects; although they may know the brand and model needed to accomplish their goal, the specifications must be written to reflect the desired characteristics of the equipment rather than requesting a specific product. In looking only at relative purchase prices, supply may purchase an unsuitable product if the specifications written are not sufficiently detailed. So, Energy officers and Supply officers, each doing their jobs independently, can misconnect as often as not in the energy conservation area. Energy officers are often reluctant to be candid with Supply about just how specific a product they really want, for fear of making Supply suspicious of motives. EOs will, however, seek advice from other EOs about how to write specifications to maximize the probability of getting Supply to order the product they want. A more straightforward procedure would be to have a higher level command bring Supply and EOs together so each can explain to the other the missions they are trying to accomplish. If EOs, by virtue of their missions, put Supply in awkward positions vis-a-vis their regulations, some higher level adjudication is clearly in order, although it is likely that closer cooperation at lower levels can accomplish quite a bit.

The users of new equipment often find its novelty an inconvenience. There is no question that timers on lights, water heaters, and air conditioners are restrictive of freedom of use. Consequently, timers are often removed or tampered with by either consumers or repair personnel. This problem will probably be reduced only by making timers more difficult to tamper with, but currently the tamperability of new equipment is one reason Energy officers do not adopt.

Lighting levels and color alterations of high pressure sodium lights cause problems, some of which can be worked around, others not. Some new lights screen out the color red, which makes working with much electronic equipment in that light dangerous--impossible for all practical purposes. The lights are adequate, however, for many other purposes. Securing the cooperation of personnel who are accustomed to working in grossly over-illuminated areas when illumination levels are lowered may be a leadership problem and largely outside the domain of EOs' persuasive powers.

5.6 INADEQUATE COMPLEMENTARY INPUTS

When regular maintenance is essential for the reasonably efficient operation of new equipment and when maintenance personnel are known to be unavailable, the equipment may not be installed regardless of the energy it might save. Similarly, if manpower is not available to read meters and analyze consumption data, installing meters will serve no purpose.

Some new technologies require particular skills for maintenance or even operation. A prime example is the EMCS, a highly sophisticated system that can be totally inoperative because of the shortage of a single complementary input. The significance of complementary inputs is shown in Table 4. Of the nine CECOS respondents working at bases without an ECMS, seven cited the "skills required to implement, operate, and maintain" the technology as a significant barrier to adoption.

5.7 THE GOAL STRUCTURE

As noted in Sect. 1 of this report, the DOD has set goals for energy conservation at Naval shore facilities. One goal calls for a 20% reduction in Btu's consumed per square foot of buildings, between 1975 and 1985. Currently, the Navy has achieved a reduction of only 11% per square foot (and only 6%, if not standardized by square footage). The Navy's progress toward the goal is monitored by NEESA, which publishes a monthly Energy audit report for each shore facility. Despite these reports and the knowledge that the Navy is not meeting the DOD goals, the goals do not appear to stimulate energy conservation.

The current goal structure is ineffective in part because it does not adequately reflect a shore facility's energy conservation accomplishments. There are several problems in this regard. First, the DOD goal is based on measures of 1975 square footage of buildings, which may be inexact since the data had to be compiled retroactively. A more important problem, however, is that the goal does not differentiate building areas devoted to energy intensive uses (such as computer facilities and various industrial processes) from areas devoted to less intensive energy functions, such as administration. This lack of differentiation leads to a variety of problems.

Since 1975, the nature of Naval operations has become increasingly energy-intensive. Examples are increases in building space devoted to computer equipment or aircraft training simulators. To the extent that a shore facility has experienced greater than average growth in such functions, it will have more difficulty reaching its goals. Similarly, to the extent that a shore facility experiences growth in low-energy building uses, such as hangars and warehouses, it will more easily reach (and may actually exceed) its goals.

There are a variety of partial solutions to the goal structure available to the Navy, some of which are under consideration currently. Although DOD's goals must be accepted as "given," the Navy could refine the goals it provides for its operations. First is the possibility of updating the 1975 base year to 1985, which would eliminate problems due to errors in the 1975 square footage figures. It would also, temporarily, reduce the impact of post-1975 construction in terms of its relative energy intensity. However, it would also fail to reflect efforts to achieve energy efficiency between 1975 and 1985. Thus, those bases that have already implemented no-cost/low-cost conservation measures would be penalized; they would have to achieve subsequent energy savings via more expensive investments.

Another improvement would involve the calculation of goals based upon the types and extent of activities occurring at a shore facility. Ultimately, it would be useful to develop an algorithm and necessary detailed data base so that NEESA could determine valid goals. For instance, a standard for energy use per square foot of administrative space would be multiplied by actual square footage for such use, to calculate its contribution to the goal. In the case of certain (particularly industrial) processes, the standard could be in terms of Btu's per "process unit," where the process unit might be a repaired aircraft or a manhour devoted to aircraft repairs. However, there are problems with simply defined process units that do not allow for mission contingencies.

Such refinement to the Navy goal structure should go hand-in-hand with an effort, on the part of each shore facility, to identify its high- and low-efficiency energy users. Such an effort requires more energy use metering.

6. RECOMMENDATIONS

Our analysis of factors affecting the implementation of energy-saving technologies at Naval shore facilities resulted in several key recommendations. Additional suggestions and background to the following recommendations can be found in earlier chapters.

- The Department of the Navy must articulate its priorities regarding increased energy efficiency more clearly and forcefully if an energy program is to be effective; its energy goals should be modified to more accurately reflect Navy priorities.

- Given their relative prominence as a source of energy-related information, coupled with the existence of important information gaps on bases, Techdata Sheets should be updated more often, cover more topics, contain more operation and maintenance information, and include more specific information on products and manufacturers.

- Improved metering, meter reading, and energy consumption analyses are required for individuals and commands to alter their energy consumption behavior intelligently.

- Any efforts to reduce energy consumption must be linked to changes in operation and maintenance procedures and availability; lack of operation and maintenance resources is a major barrier to the achievement of energy savings at shore facilities.

- At the shore facility level, the various PWD Divisions and other departments should be better integrated into shore facility energy planning. In particular:

  - Priorities for energy-related maintenance control projects should be coordinated determinations between maintenance control and Energy officers (EOs),

  - The energy conservation activities of family housing should be integrated with activities of EOs, and

  - Perceptions of conflicts between Supply personnel and EOs should be reconciled by closer coordination.

- Shared savings contracting appears to be one means by which many current barriers to the adoption of energy-conserving technologies can be overcome; guidance should be provided to shore facilities concerning its use.

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8. LIST OF ACRONYMS

A-LESP	Activity-Level Energy Systems Planning
APWO	Assistant Public Works Officer
CECOS	Civil Engineering Corps Officer School
DEIS II	Defense Energy Information System II
DOD	Department of Defense
DOE	U.S. Department of Energy
ECIP	Energy Conservation Investment Program
EFD	Engineering Field Division
EO	Energy Officer
EMCS	Energy Monitoring and Controls System
ETAP	Energy Technology Applications Program
FEP	Facility Energy Plan
FESO	Facilities Engineering Support Office
HUD	U.S. Department of Housing and Urban Development
NAVFAC	Naval Facilities Engineering Command
NCEL	Naval Civil Engineering Laboratory
NEESA	Naval Energy and Environmental Support Activity
OICC	Officer in Charge of Construction
OPNAV	Office of the Chief of Naval Operations
PWC	Public Works Center
PWD	Public Works Department
R&D	Research and Development
RDT&E	Research, Development, Testing, and Evaluation
ROICC	Resident Officer in Charge of Construction
SIR	savings-to-investment ratio

APPENDIX A

CURTAILMENT OF USE VS EFFICIENCY IMPROVEMENTS IN ENERGY CONSERVATION EFFORTS

Appendix A

CURTAILMENT OF USE VS EFFICIENCY IMPROVEMENTS IN ENERGY CONSERVATION EFFORTS

This appendix presents the background material to the arguments of Sect. 2.3 on the potentially counterproductive effects of simple energy-use curtailments as conservation efforts, as contrasted with more sophisticated attempts at improving efficiency of mission accomplishment.

In Fig. A.1, quantities of energy used are on the horizontal axis and quantities of other materials used by the Navy in the accomplishment of its mission are drawn on the vertical axis. Curve T_0 describes the current technology the Navy uses to accomplish its mission. Any combination of energy and other material on curve T_0 can permit the Navy to perform its mission to level T_0, which we can assume is current standards--the Navy's "output" of defense, in economic parlance. The relative prices at which the Navy purchases its fuel and other materials on the market are described by the slope of line MM_1. If no purchase of energy was made, the entire Navy budget could purchase OM of other materials; conversely, if all the budget were spent on fuel, OM_1 energy could be purchased. Following this example, a relative cheapening of fuel prices would be represented by a counterclockwise twisting of line MM_1. Line SS_1 shows such a relative cheapening of fuel prices and represents the shadow relative prices of fuel and other materials which the "typical" Naval facility faces in practice: parts and manpower are expensive, but more fuel can always be obtained.

The Department of the Navy's energy-reduction goals can also be illustrated. Suppose that the Navy really cannot effectively present its local commands with market prices for supplies but it can order that certain reductions in usage be made. With a considerable amount of luck the Navy could guess correctly and force a reduction of energy use from e_0 to e_1, with a reallocation of the saved funds to increased purchases of other material, from m_0 to m_1*. This choice would be particularly fortuitous because it takes individual shore facilities from points of locally efficient resource use--shadow cost ratio SS_1

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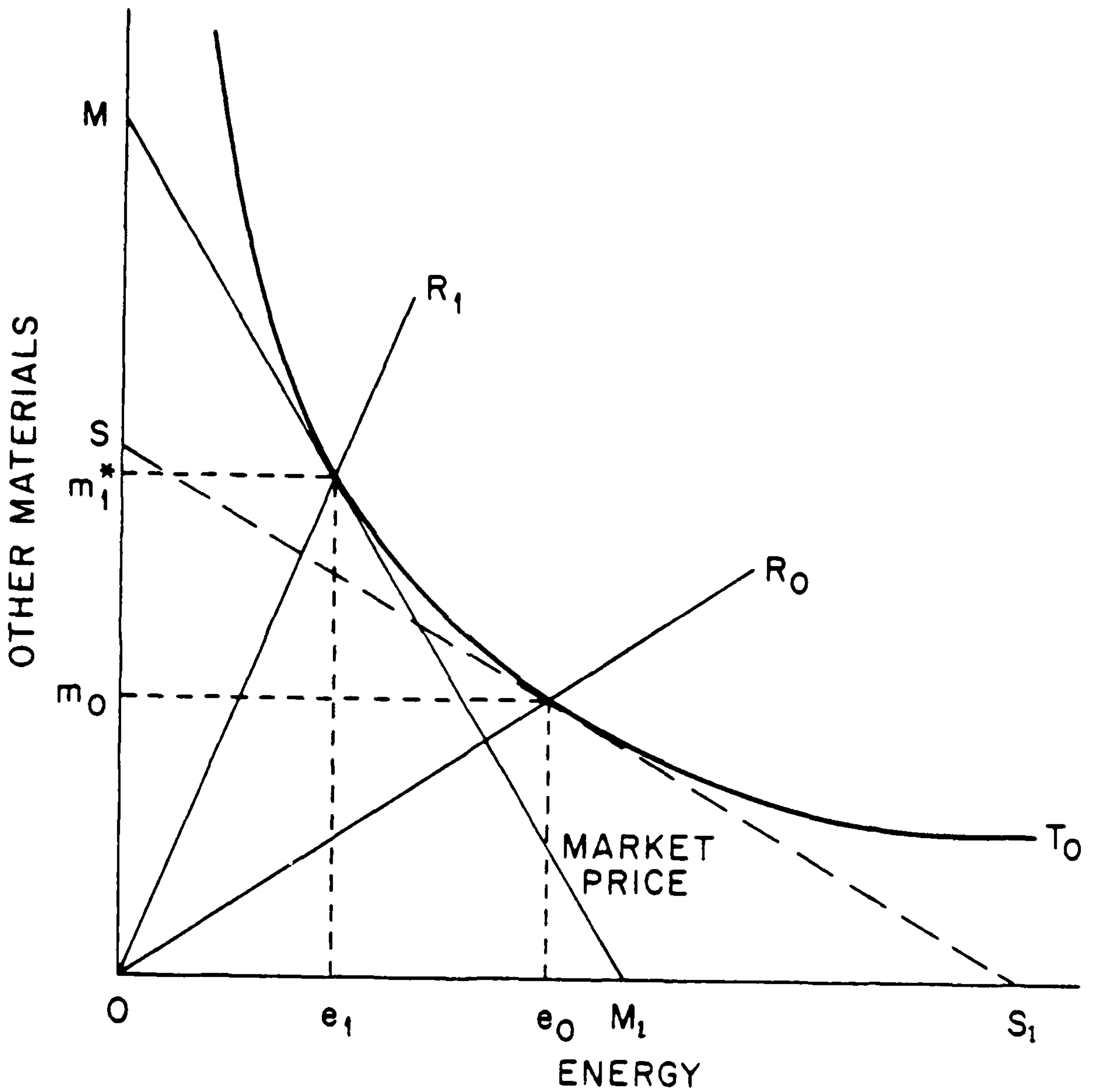

Fig. A.1. Conservation and pricing.

and benefit T_0 are tangent (ratio of changes are equal) at (e_0, m_0)--to points of organization-wide efficient resource use at (e_1, m_1), where market costs MM_1 and benefits T_0 are tangent. In this case, quantity curtailment works perfectly, but there is no reason to expect such a case to occur.

Suppose that the Navy's technology were characterized by curve T_1 in Fig. A.2 instead of T_0 in Fig. A.1. In curve T_1, as energy use is reduced, more of other materials are required to compensate than in the technology described by curve T_0. In this case, the Navy's decree to reduce energy consumption from e_0 to e_1 does not permit the local commanders to take advantage of market price and still perform their missions up to the standard represented by T_1. Instead, mission performance falls to T_1* which is delivered with e_1 energy but with m_1* of other materials.

The reader may have noticed that in both Figs. A.1 and A.2, resource combinations at the local shadow prices SS_1 lie outside the Navy's budget constraint in the marketplace, which is the area inside triangle MOM_1. In effect, only that portion of triangle SOS_1 which overlaps triangle MOM_1 represents eligible areas for locally shadow efficient, but market inefficient choices. Although the drawings have been constructed for heuristic purposes, the incidental feature of current spending exceeding a current budget constraint could illuminate one source of push for energy conservation in the Navy. Long-term pricing or budgetary limits could generate forces to find an efficient manner of operating which would stay within acceptable, long-term budgetary limits.

Figure A.2 also illustrates what appears to be a common concern among unit commanders. Conservation has a reputation of involving naively motivated quantity curtailments without regard for the costs of curtailment. A loss function exists for the reduction in Naval defense output from T_1 to T_1*, and the social valuation of the loss (i.e., how much society would be willing to pay to keep defense at T_1) could be large or small regardless of the magnitude of the change from T_1 to T_1*. Many Naval personnel are concerned that energy conservation efforts will result in their inability to accomplish their assigned

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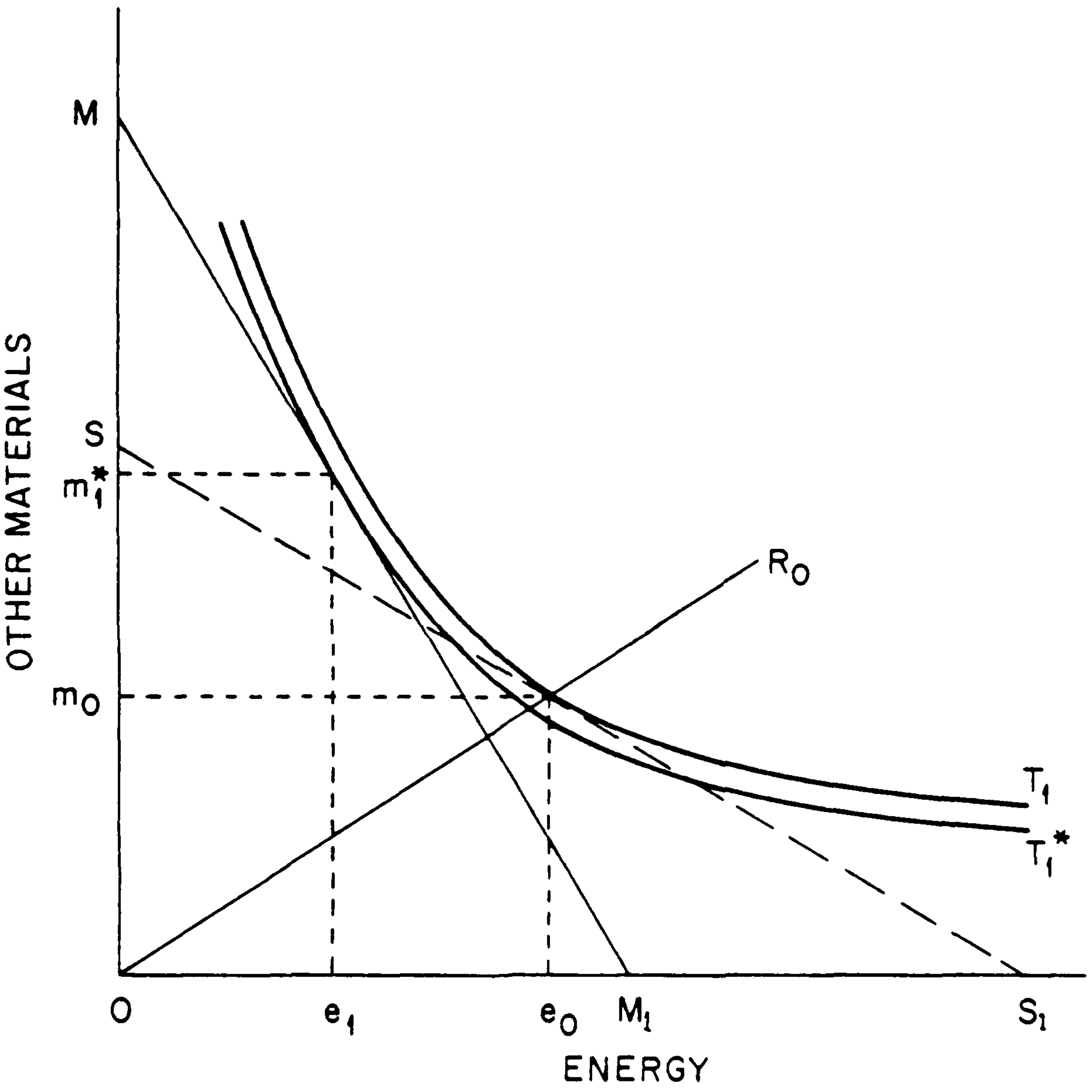

Fig. A.2. Conservation and output-reducing curtailment.

missions and an overall reduction in the Navy's ability to do so. Suppose, for example, that in the technological circumstances, an economy-minded Department of the Navy or Congress instituted a policy of no increase in purchase of other materials when energy consumption is reduced from e_0 to e_1. The combination of resources (e_1, m_0) would permit only a lower defense output than T_0.

It is possible that the concerns expressed are exaggerated, although genuine. If personnel have spent most of their careers operating in the region of Naval defense technology around ray R_0 (a line describing ratios of other materials to energy) in Fig. A.1, they may have very little awareness of what is available in the technological vicinity of ray R_1. The Navy clearly has some educational work cut out for itself to inform its officers about alternative techniques of mission accomplishment which are quite different from current practices.

APPENDIX B

NAVY SHORE FACILITY SITE VISIT PROTOCOL

Appendix B

NAVY SHORE FACILITY SITE VISIT PROTOCOL

Name:______________________ Base:______________________

Position:______________________ Date:______________________

Introductory Remarks

The Naval Civil Engineering Laboratory has requested that Oak Ridge National Laboratory complete a study of factors affecting the adoption of energy-conserving technologies at Naval shore facilities. As part of this study we would like to ask you a number of questions.

Respondent Traits

1. How long have you had your current job as ______________________ at this base?

2. What kind of energy-related training and prior job experience have you had?

3. In your current job, how important do you think energy conservation is compared with other goals? What are the important goals other than energy conservation? What are your various collateral duties other than energy conservation?

4. What role do you have in deciding what energy-saving technologies and practices get used on this base?

5. Whom do you call upon for advice when making energy-related decisions?

6. What literature have you found to be most helpful to you in making energy-related decisions?

7. What use are the Facility Energy Plan and Energy Instructions to you?

8. Do you consider or calculate savings to investment ratios when deciding which energy technologies to implement on base? If not, why not?

9. What other sources of information have been helpful?

10. Have you had much contact with product sales persons? If so, what effect has it had on your thinking and on your choices of energy conserving technologies?

11. How long a payback period can you afford for a $10-25K investment in an energy-conservation project at this base?__________________

12. For a $50-75K project?______________________

13. For a $200K project?______________________

14. What is your best guess at an annual rate of increase or decrease for energy prices, after inflation, between now and 1990?________________

Site and Situation Characteristics

1. What is the highest ranking officer on this base who has asked about energy conservation on a regular basis?

2. Are there influential people on this base whom you would describe as promoters of energy conservation? If yes, who?

3. How important do you think energy conservation is in your job performance report?

4. What is the standard procedure for deciding to purchase energy-conserving equipment?

   For local O&M expenditures:

   For ECIP expenditures:

   For ETAP expenditures:

5. Approximately how many working energy meters exist on your base? ________

6. Approximately how many of these are read on a regular basis? ____________

Technology Characteristics

1. Consider the following lighting system retrofits

   A. Reduced wattage bulbs

      1. Installed? YES / NO If Yes, what was the extent of the replacement?

      ____

      2. Respondent participated? YES / NO

      3. If Yes (No) to A.1. what were the reasons for trying (not trying) this energy- conserving retrofit? ____________________

      ____

      ____

      ____

   B. Conversion from incandescent to fluorescent lighting

      1. Conversion? YES / NO If Yes, what was the extent of conversion?

      ____

      2. Respondent participated? YES / NO

      3. If Yes (No) to B.1. what were the reasons for trying (not trying) this energy- conserving retrofit? ____________________

      ____

      ____

      ____

   C. Integral light switches

      1. Installed? YES / NO If Yes, what was the extent of the replacement?

      ____

      2. Respondent participated? YES / NO

      3. If Yes (No) to C.1. what were the reasons for trying (not trying) this energy- conserving retrofit? ____________________

      ____

      ____

D. Conversion to high pressure sodium lights

1. Installed? YES / NO If Yes, what was the extent of the replacement? ______________________________

____

2. Respondent participated? YES / NO

3. If Yes (No) to D.1. what were the reasons for trying (not trying) this energy- conserving retrofit? ______________________________

____

____

E. Other: ______________________________

1. Respondent participated YES / NO

2. What were the reasons for trying this energy-conserving retrofit?

____

____

____

F. Other: ______________________________

1. Respondent participated YES / NO

2. What were the reasons for trying this energy-conserving retrofit?

____

____

____

2. Have any roofs on this base been sprayed with polyurethane foam insulation? If NO, What were the reasons for not trying this type of insulation?

____

____

____

If YES:

A. Project 1: ______________________________

1. Respondent participated? YES / NO

2. What were the reasons for trying this energy-conserving retrofit?

____

____

____

B. Project 2: ______________________________

1. Respondent participated? YES / NO

2. What were the reasons for trying this energy-conserving retrofit?

____

____

____

3. Have any controls been installed in the base's buildings to automatically adjust interior temperatures? If NO, what were the reasons for not trying automatic setback thermostats or other such building controls?

____

____

____

A. Project 1: ______________________________

1. Respondent participated? YES / NO

2. What were the reasons for trying this energy-conserving device?

____

____

____

B. Project 2: ____________________

1. Respondent participated? YES / NO

2. What were the reasons for trying this energy-conserving device?

____

____

____

4. Have any solar water heaters been installed on this base? ________

If No, Why not? ____________________

____

____

If Yes:

A. Project 1: ____________________

1. Respondents participated YES / NO

2. What were the reasons for installing this type of water heater?

____

____

____

B. Project 2: ____________________

1. Respondents participated YES / NO

2. What were the reasons for installing this type of water heater?

____

____

____

5. What other major conservation projects have occurred on this base?

A. Project 1: ______________________________

1. Respondent participated? YES / NO

2. What were the reasons for engaging in this energy-conserving project?

____

____

____

B. Project 2: ______________________________

1. Respondent participated? YES / NO

2. What were the reasons for engaging in this energy-conserving project?

____

____

____

Additional Comments

APPENDIX C

CECOS ENERGY CONSERVATION QUESTIONNAIRE

Appendix C

CECOS ENERGY CONSERVATION QUESTIONNAIRE

The Naval Civil Engineering Laboratory has hired Oak Ridge National Laboratory to complete a study of factors affecting the adoption of energy-conserving technologies at Naval shore facilities. As part of this study we would like you to answer the following questions, and return the questionnaire to the course instructor by noon tomorrow. Please feel free to express your opinions. All responses will be kept strictly confidential.

1. What is the title of your current position? ______________________

2. Is there a full-time energy officer/coordinator at your activity? YES__ NO__

   If NO, what percent of a man-year goes towards centralized energy conservation planning at your activity? _________

3. Is there a functioning energy conservation organization or network at your activity? YES___ NO___

4. What level of support and cooperation for energy conservation planning and implementation have you received from the following people at your activity?

	No support or cooperation						Strong support and cooperation	No basis for judgement
Activity commanding officer	1	2	3	4	5	6	7	9
Operational unit commanders (other than activity commanding officer)	1	2	3	4	5	6	7	9
Public works officer	1	2	3	4	5	6	7	9
Assistant public works officer	1	2	3	4	5	6	7	9
Energy conservation officer	1	2	3	4	5	6	7	9
Family housing personnel	1	2	3	4	5	6	7	9
Facilities planning personnel	1	2	3	4	5	6	7	9
Engineering personnel	1	2	3	4	5	6	7	9
Maintenance and control personnel	1	2	3	4	5	6	7	9
Utilities payment processing personnel	1	2	3	4	5	6	7	9

5. Is your activity metered well enough so that you can identify large users of energy? YES__ NO__

6. If "YES" to question 5, are these meters read on a regular basis? YES__ NO__

7. What differences, if any, do you see between energy conservation and improvement in efficiency of energy use? No essays please - just reactions to these two concepts.

8. Do you think the mission of your activity can be maintained intact while decreasing energy expenditures? Check one.

   ___ Absolutely not
   ___ Probably not
   ___ Maybe not
   ___ Maybe so
   ___ Probably so
   ___ Definitely so

9. For each of the information sources listed below, please indicate how useful you have found it to be in deciding upon energy-conserving actions at your activity. We also would like to know what kind of experiences your assessment is based upon.

Source	Usefulness: Not at all useful 1	2	3	4	5	6	Extremely useful 7	Direct experience only	No direct experience; Judgement based only on other people's reports	Both direct experience and hearsay
Organizations:										
Naval Civil Engineering Laboratory (NCEL) (other than FESO)	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Facilities Engineering Support Office (FESO)	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Engineering Field Division	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Naval Engineering and Environmental Support Activity (NEESA)	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Major Claimant/Sub-Major Claimant	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
U.S. Department of Energy	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Other Federal Agencies	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Publications:										
P manuals	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Techdata sheets	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Waste watchers guide	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Technical memoranda, notes, and reports	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
OPNAV instructions	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
NAVFAC instructions	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Local instructions	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Design manuals	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
NAVFAC guide specifications	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Operation and maintenance manuals	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Facility energy plans	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO
Publications by others (gov't, industry, etc.) - please list outstanding examples	1	2	3	4	5	6	7	YES/NO	YES/NO	YES/NO

THE FOLLOWING QUESTIONS DEAL WITH VARIOUS TECHNOLOGIES WHICH MAY HAVE BEEN INSTALLED AT YOUR ACTIVITY.

10. Have any solar water heaters been installed at your activity or has funding been requested for them? YES __ NO __

If YES, skip to Section B. If NO, complete Section A.

A. How important were each of the following considerations in the decision not to install, or not to request funding for, solar water heaters?

	Not an important barrier/incentive to adoption			Very important barrier/incentive to adoption	Circle One:	
Savings to investment ratio	1	2	3	4	INCENTIVE	BARRIER
Annual energy savings	1	2	3	4	INCENTIVE	BARRIER
Annual O&M savings (or additional costs)	1	2	3	4	INCENTIVE	BARRIER
Start-up and periodic investment costs	1	2	3	4	INCENTIVE	BARRIER
Payback period	1	2	3	4	INCENTIVE	BARRIER
Effort required to obtain funding	1	2	3	4	INCENTIVE	BARRIER
Uncertainties	1	2	3	4	INCENTIVE	BARRIER
Ability to adopt on trial basis	1	2	3	4	INCENTIVE	BARRIER
Skills required to implement, operate, and maintain	1	2	3	4	INCENTIVE	BARRIER
Ability to document energy savings	1	2	3	4	INCENTIVE	BARRIER
Improving public awareness of energy conservation	1	2	3	4	INCENTIVE	BARRIER

B. How important were each of the following considerations in the decision to install, or request funding for, solar water heaters?

	Not an important barrier/incentive to adoption			Very important barrier/incentive to adoption	Circle One:	
Savings to investment ratio	1	2	3	4	INCENTIVE	BARRIER
Annual energy savings	1	2	3	4	INCENTIVE	BARRIER
Annual O&M savings (or additional costs)	1	2	3	4	INCENTIVE	BARRIER
Start-up and periodic investment costs	1	2	3	4	INCENTIVE	BARRIER
Payback period	1	2	3	4	INCENTIVE	BARRIER
Effort required to obtain funding	1	2	3	4	INCENTIVE	BARRIER
Uncertainties	1	2	3	4	INCENTIVE	BARRIER
Ability to adopt on trial basis	1	2	3	4	INCENTIVE	BARRIER
Skills required to implement, operate, and maintain	1	2	3	4	INCENTIVE	BARRIER
Ability to document energy savings	1	2	3	4	INCENTIVE	BARRIER
Improving public awareness of energy conservation	1	2	3	4	INCENTIVE	BARRIER

C. Have there been any problems relating to the installation, maintenance, or operation of the solar water heaters which have limited the amount of energy savings resulting from them?

D. Any other comments on solar water heaters?

11. Have any high pressure sodium lights been installed at your activity or has funding been requested for them? YES __ NO __

If YES, skip to Section B. If NO, complete Section A.

A. How important were each of the following considerations in the decision not to install, or not to request funding for, high pressure sodium lights?

	Not an important barrier/incentive to adoption			Very important barrier/incentive to adoption	Circle One:	
Savings to investment ratio	1	2	3	4	INCENTIVE	BARRIER
Annual energy savings	1	2	3	4	INCENTIVE	BARRIER
Annual O&M savings (or additional costs)	1	2	3	4	INCENTIVE	BARRIER
Start-up and periodic investment costs	1	2	3	4	INCENTIVE	BARRIER
Payback period	1	2	3	4	INCENTIVE	BARRIER
Effort required to obtain funding	1	2	3	4	INCENTIVE	BARRIER
Uncertainties	1	2	3	4	INCENTIVE	BARRIER
Ability to adopt on trial basis	1	2	3	4	INCENTIVE	BARRIER
Skills required to implement, operate, and maintain	1	2	3	4	INCENTIVE	BARRIER
Ability to document energy savings	1	2	3	4	INCENTIVE	BARRIER
Improving public awareness of energy conservation	1	2	3	4	INCENTIVE	BARRIER

B. How important were each of the following considerations in the decision to install, or request funding for, high pressure sodium lights?

	Not an important barrier/incentive to adoption			Very important barrier/incentive to adoption	Circle One:	
Savings to investment ratio	1	2	3	4	INCENTIVE	BARRIER
Annual energy savings	1	2	3	4	INCENTIVE	BARRIER
Annual O&M savings (or additional costs)	1	2	3	4	INCENTIVE	BARRIER
Start-up and periodic investment costs	1	2	3	4	INCENTIVE	BARRIER
Payback period	1	2	3	4	INCENTIVE	BARRIER
Effort required to obtain funding	1	2	3	4	INCENTIVE	BARRIER
Uncertainties	1	2	3	4	INCENTIVE	BARRIER
Ability to adopt on trial basis	1	2	3	4	INCENTIVE	BARRIER
Skills required to implement, operate, and maintain	1	2	3	4	INCENTIVE	BARRIER
Ability to document energy savings	1	2	3	4	INCENTIVE	BARRIER
Improving public awareness of energy conservation	1	2	3	4	INCENTIVE	BARRIER

C. Have there been any problems relating to the installation, maintenance, or operation of the lights which have limited the amount of energy savings resulting from them?

D. Any other comments on high pressure sodium lights?

12. Has an energy monitoring and control system (EMCS) been installed at your activity or has funding been requested for one? YES __ NO __

If YES, skip to Section B. If NO, complete Section A.

A. How important were each of the following considerations in the decision not to install, or not to request funding for, an EMCS?

	Not an important barrier/incentive to adoption		Very important barrier/incentive to adoption		Circle One:	
Savings to investment ratio	1	2	3	4	INCENTIVE	BARRIER
Annual energy savings	1	2	3	4	INCENTIVE	BARRIER
Annual O&M savings (or additional costs)	1	2	3	4	INCENTIVE	BARRIER
Start-up and periodic investment costs	1	2	3	4	INCENTIVE	BARRIER
Payback period	1	2	3	4	INCENTIVE	BARRIER
Effort required to obtain funding	1	2	3	4	INCENTIVE	BARRIER
Uncertainties	1	2	3	4	INCENTIVE	BARRIER
Ability to adopt on trial basis	1	2	3	4	INCENTIVE	BARRIER
Skills required to implement, operate, and maintain	1	2	3	4	INCENTIVE	BARRIER
Ability to document energy savings	1	2	3	4	INCENTIVE	BARRIER
Improving public awareness of energy conservation	1	2	3	4	INCENTIVE	BARRIER

B. How important were each of the following considerations in the decision to install, or request funding for an EMCS?

	Not an important barrier/incentive to adoption		Very important barrier/incentive to adoption		Circle One:	
Savings to investment ratio	1	2	3	4	INCENTIVE	BARRIER
Annual energy savings	1	2	3	4	INCENTIVE	BARRIER
Annual O&M savings (or additional costs)	1	2	3	4	INCENTIVE	BARRIER
Start-up and periodic investment costs	1	2	3	4	INCENTIVE	BARRIER
Payback period	1	2	3	4	INCENTIVE	BARRIER
Effort required to obtain funding	1	2	3	4	INCENTIVE	BARRIER
Uncertainties	1	2	3	4	INCENTIVE	BARRIER
Ability to adopt on trial basis	1	2	3	4	INCENTIVE	BARRIER
Skills required to implement, operate, and maintain	1	2	3	4	INCENTIVE	BARRIER
Ability to document energy savings	1	2	3	4	INCENTIVE	BARRIER
Improving public awareness of energy conservation	1	3	3	4	INCENTIVE	BARRIER

C. Have there been any problems relating to the installation, maintenance, or operation of the EMCS which have limited the amount of energy savings resulting from the system?

D. Any other comments on EMCS?

14. Is there another energy conservation action at your activity about which you have particular opinions? YES __ NO __

If YES, name the action and complete Section A. NAME: ____________________

A. How important were each of the following considerations in the decision to implement this energy conservation action?

	Not an important barrier/incentive to adoption		Very important barrier/incentive to adoption		Circle One:	
Savings to investment ratio	1	2	3	4	INCENTIVE	BARRIER
Annual energy savings	1	2	3	4	INCENTIVE	BARRIER
Annual O&M savings (or additional costs)	1	2	3	4	INCENTIVE	BARRIER
Start-up and periodic investment costs	1	2	3	4	INCENTIVE	BARRIER
Payback period	1	2	3	4	INCENTIVE	BARRIER
Effort required to obtain funding	1	2	3	4	INCENTIVE	BARRIER
Uncertainties	1	2	3	4	INCENTIVE	BARRIER
Ability to adopt on trial basis	1	2	3	4	INCENTIVE	BARRIER
Skills required to implement, operate, and maintain	1	2	3	4	INCENTIVE	BARRIER
Ability to document energy savings	1	2	3	4	INCENTIVE	BARRIER
Improving public awareness of energy conservation	1	2	3	4	INCENTIVE	BARRIER

B. Have there been any problems relating to installation, maintenance, or operation regarding this action which have limited the amount of energy savings resulting from the action?

C. Any other comments on this action?